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SAFETY REQUIREMENTS AND PROCESS FOR ATTACHED PAYLOADS: THE LOW TEMPERATURE MICROGRAVITY PHYSICS FACILITY

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Descriptions of the payload safety requirements and processes that attached payloads must satisfy to meet to fly on the Shuttle or HTV and to be attached to the ISS from the perspective of a payload safety engineer are presented.

Introduction

Payloads are required to provide assurances that all safety requirements have been met for flight prior to being installed on a launch vehicle. The design of the payload must be reviewed by the launch vehicle organization to confirm that appropriate safety features have been implemented. If the payload is launched on the Space Transportation System (STS), then several reviews will be held independently at the NASA Johnson Space Center (JSC) and the NASA Kennedy Space Center (KSC). As the launch vehicle operator, JSC assures the safety of the Space Shuttle in flight, and as the launch facility operator, KSC assures the safety of ground and launch operations, including Shuttle integration. If launching on a Japanese expendable rocket, then the payload and it's GSE will be reviewed by NASDA at a facility such as Tanegashima Space Center (TNSC) to assure the safety of ground and launch operations for both the H-IIA rocket and its facilities.

Payload Safety Requirements

Payloads that will be installed on the International Space Station (ISS) are required to comply with safety requirements of NSTS 1700.7B ISS Addendum.[1] If transportation to the ISS will be by a H-IIA rocket Transfer Vehicle (HTV), then payloads will have to meet the safety requirements of NASDA-STD-14B.[2] These document stipulates that fault tolerance is the guiding principle by which payloads are to be designed. Therefore, the Space Transportation Systems (STS) and NASDA policies on payloads are that they must be able to withstand faults without creating a hazard. A hazard that can result in damage to ISS or H-IIA/HTV equipment, in a non-disabling personnel injury or requires the use of unscheduled safing procedures by the ISS, H-IIA /HTV or one of their payloads or cargo is defined as a critical hazard. As such, a critical hazard requires that the payload have single fault tolerance which means that two inhibits must be overcome before the hazard can be realized. Two fault tolerance requires three inhibits to fail before a catastrophic hazard can occur. Catastrophic hazards have the potential for disabling or fatal personnel injury, loss of the ISS or H-IIA/HTV, ground facilities or the ISS or H-IIA/HTV equipment.

There is one other category of hazards, other than failure tolerance, called "Design for Minimum Risk" (DFMR). These hazards are controlled by compliance with specific requirements of the two aforementioned documents , such as structures, pressure vessels, flammability, functional pyrotechnics, etc., thereby greatly minimizing the likelihood of failure.

For example, structures are DFMR because they have to be designed using specific factors of safety on yield and ultimate, and the payload agrees to implement fracture control and perform environmental testing (such as vibration and thermal/vacuum tests) and needed inspection. Should the structure be classified as fracture critical then Nondestructive Evaluation (NDE) will done using an agreed upon method.

For unique Ground Support Equipment (GSE) additional requirements on their design and operations at the STS launch site can be found in the joint 45th Space Wing/Kennedy Space Center (KSC) Handbook, 45 SPW HB S-100/KHB 1700.7 and NASDA-STD-14B for those launching from Japan.[3]

Safety Review Process

The safety review process is an iterative process as stipulated in NSTS/ISS 13830.[4] Typically, there are three Flight Safety Reviews (Phase O/I, II, III) held at the JSC and three separate Ground Safety Review held at the KSC for STS launches. Similarly, there is a minimum of three reviews at TNSC for NASDA launches. Figure 1 shows as a typical schedule as to when to hold the various reviews during a project life cycle. Each payload is required to generate a Safety Data Package (SDP) for each review; therefore, there is a Flight Phase O/I SDP and a corresponding Ground Phase O/I SDP except for launches from Japan where the SDP is a combined Flight/Ground Phase O/I. For shuttle manifested payloads, each SDP is to be submitted to each NASA Center separately and if the package acceptable an official safety review is held 45 days later whereby the payload is reviewed for safety. Approval to proceed to the next phase of reviews is granted upon the signing of the hazard reports by the PSRP chairman.

Attaining the Payload Safety Review Panel (PSRP)/Ground Safety Review Panel (GSRP) approval of the safety analysis that reflects the payload preliminary design and its operations scenario is the main focus of the phase O/I safety review. Specified minimum safety analyses and activities are required to be accomplished at each phase of system development and documented for approval. Documentation is usually in the form of a Safety Data Package (SDP). Therefore, the Phase O/I SDP consists of a hazard assessment of the hardware and its operation scenario at the preliminary design stage. Proof that each feature designed to control a given hazard is in fact in place and functional is required. Necessary proofs are determined from the Safety Analysis, listed as "Verification Methods" on the Hazard Report, refined and occasionally redefined in the documentation review process, and reported without fail when completed. The hazard analysis will identify all unique hazards and hazard causes and is documented on a Hazard Report, Form 542B-1. Should the hazard assessment determined that all of the hazards are "standard" i.e. the hazard, hazard causes, hazard controls and safety verification method are the same as those listed on JSC Form 1230, then only this form is required to be completed. For STS launches, the payload will also submit a Fracture Control Plan and Structural Verification Plan to the JSC Structures Working Group for approval at this time. These plans formalize the agreements between the payload and the STS on how these disciplines will be implemented.

The Phase II SDP contains the updated hazard assessment that reflects the Critical Design Review (CDR)-level design and operations scenario of the payload. The hazard analysis identifies all hazards and hazard causes, defines how the hazard will be controlled and documents finalized,, specific safety verification and on-orbit verification/reverification methods that will be implemented such as test plan, analysis, and/or inspection requirements. During the Phase II Safety Review, the payload is seeking panel approval at this stage of development/qualification.

The purpose of the Phase III Safety Review is to obtain PSRP/GSRP approval of the SDP and safety compliance data that reflects the safety verification findings. Passing this review allows the payload to be integrated into the launch vehicle and Certificate of Flight Readiness (CoFR) process to proceed.

The phase III safety reviews are normally held at launch –7 months for flight and launch –5 months for ground. Both flight and ground safety reviews and ground safety certification must be completed 30 days prior to shipment of flight hardware and its GSE to the launch site.

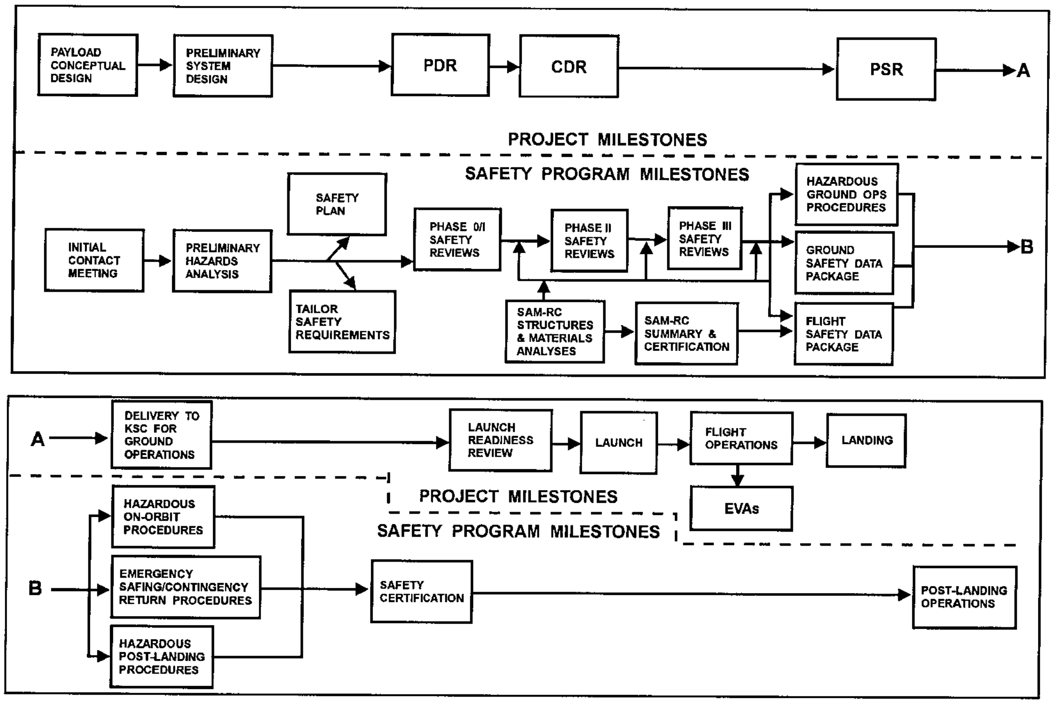

Fig. 1 Typical Safety Schedule

Conclusion

The NASA ISS safety requirements and review process is well defined for payloads using the STS; however, for payloads launching on a NASDA HTV rocket , the process is define but the implementation is in its infancy and requires more coordination. This process will become better as soon as more payloads are manifested for flight.

Acknowledgement

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References

[1]"Safety Policy and Requirements for Payloads Using the International Space Station," NSTS 1700.7B ISS Addendum, December 1995.

[2]"Standard General Requirements for Safe Design and Operation of Launch Vehicle Payloads," NASDA-STD-14, September 25, 1998.

[3]"Space Shuttle Payload Ground Safety Handbook,"45SPW HB S-10, KHB 1700.7B, 1 September 1992.

[4]"Payload Safety Review and Data Submittal Requirements for Payloads Using the Space Shuttle International Space Station," NSTS/ISS 13830 Rev C, July 1998.